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(54) **Sulfated glycosaminoglycanoid derivatives.**

(57) The invention relates to a sulfated glycosaminoglycanoid derivative or a pharmaceutically acceptable salt thereof, of which the functional N-sulfate, N-acetate, and hydroxy groups, are replaced by alkoxy, aryloxy, aralkoxy, O-sulfate, or $OALK(OALK)_nOX$ groups (wherein ALK is an aliphatic hydrocarbon group, n is 0-5, and X is an alkyl or aryl group), provided that at least two functional groups are not replaced by O-sulfate. The compounds have antithrombotic and smooth muscle cell proliferation inhibiting activities.

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The invention concerns a sulfated glycosaminoglycanoid derivative or a pharmaceutically acceptable salt thereof, of which the functional N-sulfate, N-acetate, and hydroxy groups, are replaced by alkoxy, aryloxy, aralkoxy, O-sulfate, or OALK(OALK)$_n$OX groups, wherein ALK is an aliphatic hydrocarbon group, n is 0-5, and X is an alkyl or aryl group, provided that at least two functional groups are not replaced by O-sulfate. The invention is further related to a process for the preparation of said derivative, a pharmaceutical composition containing the same, as well as to a use of sulfated glycosaminoglycanoid derivatives for the preparation of a medicament.

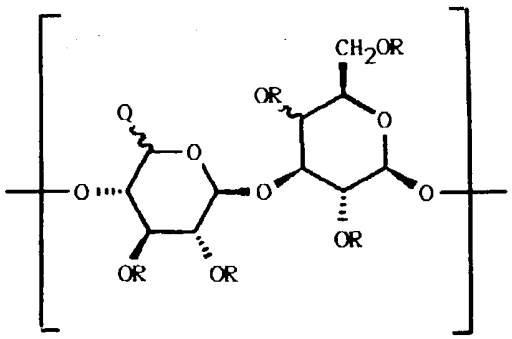
Sulfated glycosaminoglycan derivatives are known. European patent EP 84,999, for instance, discloses sulfated pentasaccharides of the chemical class of glycosaminoglycans having antithrombotic activity. These known compounds can possess, apart from hydroxy groups, O-sulfate, N-sulfate, and N-acetyl groups, whereas the anomeric hydroxy group is sometimes replaced by a methoxy group. When all functional groups are replaced by O-sulfate, persulfated carbohydrates such as maltose octasulfate as disclosed in EP 230,023 are obtained, but such compounds normally not longer have the desired antithrombotic activity, and therefore they are not encompassed in this invention. Also glycosaminoglycan derivatives having a non-sulfated anomeric hydroxy group but all other functional groups being replaced by O-sulfate, do not longer have the desired antithrombotic activity. Apart from the anomeric hydroxy group at least one other functional group should be alkoxy, aryloxy, aralkoxy, or OALK(OALK)$_n$OX, and preferably alkoxy.

In contrast to the known glycosaminoglycan derivatives, the present sulfated glycosaminoglycanoid derivatives do not have free hydroxy groups, nor do they possess N-sulfate or N-acetyl groups.

It has now been found that the compounds of this invention have a better binding affinity to antithrombin III with respect to the naturally occuring pentasaccharide of European patent EP 84,999, which results in a better pharmacokinetic profile, longer half-life times, and lower therapeutic doses and thus lesser side-effects. Furthermore, the compounds of this invention have a substantially better heparin cofactor II (HCII) mediated antithrombin activity, and are, therefore, more effective as thrombin generation inhibitors than the prior art compounds. The sulfated glycosaminoglycanoid derivatives can also be used as inhibitors for smooth muscle cell proliferation, and for the treatment of angiogenesis, cancer, and retrovirus infections, like HIV.

The inclusion of alkyl, aryl, or aralkyl functionalized saccharide units gives further a very important synthetic advantage over the prior art compounds. By functionalizing the hydroxy groups with alkyl, aryl, or aralkyl groups, it is in most cases redundant to prepare temporarily protected carbohydrates, which makes the synthetic pathway considerably shorter and simpler, whereas the replacement of the glucosamine units by glucose units further simplifies the synthesis of the saccharides significantly. Moreover, an additional advantage of the synthesis of the compounds of the invention is that the nature of the temporarily protective groups, which are necessary for the protection of the hydroxy groups to be sulfated, is not critical.

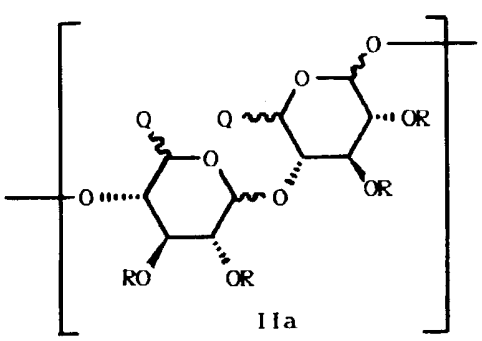
Preferred compounds according to this invention are sulfated glycosaminoglycanoid derivatives, comprising the disaccharide unit having the formula I



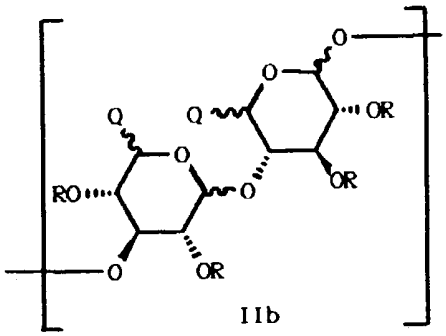
I

in which the twitched lines denote an α or β bond, each of the groups R are independently selected from the group consisting of alkyl, aryl, aralkyl, and sulfate; and Q is selected from carboxylate and the CH_2OR group, or a pharmaceutically acceptable salt thereof.

Other preferred compounds are the sulfated glycosaminoglycanoid derivatives comprising the disaccharide unit having the formula IIa or IIb



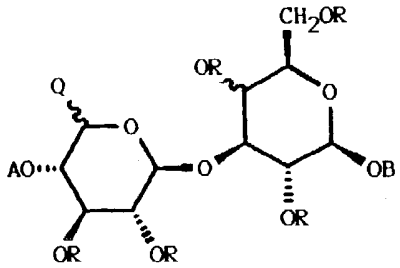
IIa



IIb

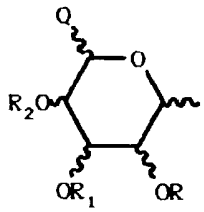
in which the twitched lines denote an α or β bond, each of the groups R are independently selected from the group consisting of alkyl, aryl, aralkyl, and sulfate, and each of the groups Q are independently selected from the group consisting of the carboxylate and the CH_2OR group, or a pharmaceutically acceptable salt thereof.

Particularly useful compounds according to this invention are the sulfated glycosaminoglycanoid derivatives having the formula III



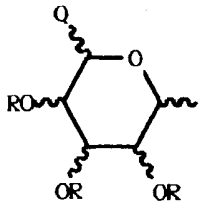
III

in which the twitched lines denote an α or β bond, each of the groups R are independently selected from the group consisting of alkyl, aryl, aralkyl, and sulfate;
Q is selected from carboxylate and the CH_2OR group;
A is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, and a carbohydrate group having the formula IV



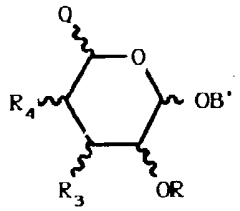
IV

in which the twitched lines, Q, and R have the previously given meanings, one of the groups R_1 and R_2 is alkyl, aryl, aralkyl, or sulfate, whereas the other is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, and a carbohydrate group having the formula V



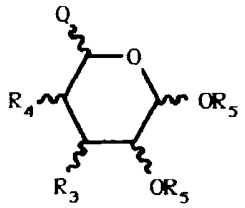
V

in which the twitched lines, Q, and R have the previously given meanings; and
B is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, $ALK(OALK)_nOX$ (wherein ALK is an aliphatic hydrocarbon group, n is 0-5, and X is an alkyl or aryl group), and a carbohydrate group having the formula VI



VI

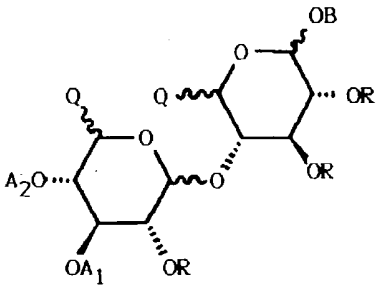
in which the twitched lines, Q, and R have the previously given meanings, one of the groups R_3 and R_4 is alkoxy, aryloxy, aralkoxy, or O-sulfate, whereas the other is a bond, and B' is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, $ALK(OALK)_nOX$ (wherein ALK, n, and X have the previously given meanings), and a carbohydrate group having the formula VII



VII

in which the twitched lines, Q, R_3, and R_4 have the previously given meanings, and each of R_5 has independently the meaning previously given for R or is $ALK(OALK)_nOX$ (wherein ALK, n, and x have the previously given meanings), or a pharmaceutically acceptable salt thereof.

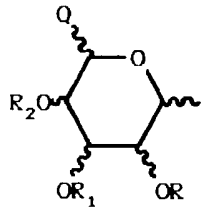
Also useful are the sulfated glycosaminoglycanoid derivatives having the formula VIII



VIII

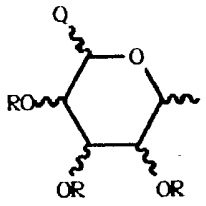
in which the twitched lines denote an α or β bond, each of the groups R are independently selected from the group consisting of alkyl, aryl, aralkyl, and sulfate, each of the groups Q are independently selected from the group consisting of carboxylate and the CH_2OR group, one of the groups A_1 and A_2 is alkyl, aryl,

aralkyl, or sulfate, whereas the other is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, and a carbohydrate group having the formula IV



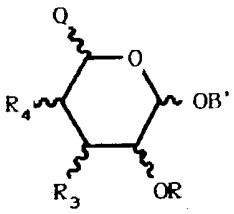
IV

in which the twitched lines, Q, and R have the previously given meanings, one of the groups R_1 and R_2 is alkyl, aryl, aralkyl, or sulfate, whereas the other is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, and a carbohydrate group having the formula V



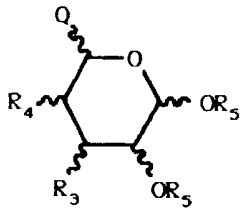
V

in which the twitched lines, Q, and R have the previously given meanings; and
B is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, $ALK(OALK)_nOX$, wherein ALK is an aliphatic hydrocarbon group, n is 0-5, and X is an alkyl or aryl group, and a carbohydrate group having the formula VI



VI

in which the twitched lines, Q, and R have the previously given meanings, one of the groups R_3 and R_4 is alkoxy, aryloxy, aralkoxy, or O-sulfate, whereas the other is a bond, and B' is selected from alkyl, aryl, aralkyl, sulfate, $ALK(OALX)_nOX$ (wherein ALK, n, and X have the previously given meanings), and a carbohydrate group having the formula VII



VII

in which the twitched lines, Q, R_3, and R_4 have the previously given meanings, and each of R_5 has independently the meaning previously given for R or is $ALK(OALK)_nOX$ (wherein ALX, n, and X have the previously given meanings), or a pharmaceutically acceptable salt thereof.

The alkyl group in the definition of R, R_1, R_2, A, A_1, A_2, X, B and B' is an unsubstituted or NR'R''-substituted, branched or unbranched alkyl group having 1-20 carbon atoms or a cyclo-alkyl group having 3-8 carbon atoms. Alkyl groups for different groups R may be different. Examples are methyl, ethyl, isopropyl, butyl, *sec*-butyl, pentyl, neopentyl, hexyl, octyl, decyl, undecyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, octadecyl, and eicosyl. Preferred are the alkyl groups having 1-6 carbon atoms. More preferred are the alkyl groups having 1-4 carbon atoms, and most preferred is a methyl group.

The group NR'R'' is an amino group wherein R' and R'' are independently selected from the group of hydrogen, alkyl (as previously defined), acyl (preferentially acyl groups derived from aliphatic hydrocarbon groups having 2-6 carbon atoms), benzyloxycarbonyl, carboxyl, and SO_3^-, or R' and R'' form together with the nitrogen atom to which they are bonded a cyclic amide or imide (examples are the phthaloylamino, succinylamino, trimellitylamino and similar groups).

The term aryl in the definition of R, R_1, R_2, A, A_1, A_2, X, B and B' means an aromatic group, preferably phenyl, which may be substituted by OH, alkyl having 1-4 carbon atoms, alkoxy having 1-4 carbon atoms, halogen (preferably fluorine, chlorine, or bromine), CF_3, or NR'R'', wherein R' and R'' have the previously given meanings.

The term aralkyl means an aralkyl group in which the alkyl moiety is an alkyl group having 1-4 carbon atoms and the aryl moiety is an aryl group as previously defined.

In the terms alkoxy, aryloxy, and aralkoxy, used in the definitions of R_3 and R_4, the alkyl, aryl, and aralkyl moieties have the same meanings as given previously for the alkyl, aryl, and aralkyl groups respectively in the definition of R, R_1, R_2, A, A_1, A_2, X, B and B'.

The term ALK means an aliphatic hydrocarbon group having 2-6 carbon atoms. ALK can be a branched or unbranched, saturated or unsaturated hydrocarbon group. Preferred ALK groups are saturated, and with more preference unbranched hydrocarbon groups. Preferred ALK groups have 2-4 carbon atoms. Examples of ALK groups are 1,2-ethanediyl, 1,3-propanediyl, 1,4-butanediyl, 1-methyl-1,2-ethanediyl, 2-propene-1,3-diyl, and 2,4-dimethyl-1,4-butanediyl. Most preferred is the 1,2-ethanediyl group.

The subscript "n" in $ALK(OALK)_nOX$ is an integer between 0 and 5, and preferably between 1 and 3. Most preferred n is 1.

The term "α or β bond" means that the configuration of the concerned bond is respectively trans or cis with respect to the anomeric bond in the concerned saccharide unit.

The term sulfated glycosaminoglycanoid derivative means a sulfated glycosaminoglycan derivative, in which the N-sulfate group(s) is (are) replaced by alkoxy, aryloxy, aralkoxy, and preferably by O-sulfate groups, whereas one or more of the uronic acid units may be replaced by carbohydrate units having the group CH_2OR instead of a carboxylate group. A glycosaminoglycan is a carbohydrate which belongs to the well-known chemical class of glycosaminoglycans.

Preferred compounds have R is alkyl, and more preferably methyl, at sites where the corresponding natural occurring glycosaminoglycans possess a free hydroxy group or an acetamido group, and R is sulfate at sites where the corresponding natural occurring glycosaminoglycans possess a sulfate group. Compounds having 5-8 saccharide units (penta to octa-saccharides) are particularly preferred.

It is generally believed that multipoint key polar interactions are of essential importance throughout molecular biology for ensuring high selectivity in non-covalent molecular associations, and that substitution of only one of the key hydroxy groups of an oligosaccharide by a hydrophobic group (and invariably a number of the hydroxy groups prove outstandingly essential to complex formation) can result in complete loss of the affinity by the protein. Remarkably, however, the preferred compounds of this invention having O-alkyl and O-sulfate groups without having free hydroxy groups, still show the full-blown activity.

The counter-ions which compensate the charged moieties are pharmaceutically acceptable counter-ions, like hydrogen, or more preferably alkali or earth-alkali metal ions, like sodium, calcium, or magnesium.

The carbohydrates according to this invention may be prepared according to well known methods described and used for the synthesis of polysaccharides. In this respect, particular reference is made to the previously mentioned European patent EP 84,999, in which methods for the synthesis of polysaccharides are disclosed.

A suitable process for the preparation of the sulfated glycosaminoglycanoid derivative of this invention is characterized in that protected monosaccharides are coupled to give protected disaccharides, which are optionally further coupled to tri- to hexasaccharides, after which the protective groups are partially or completely cleaved and free hydroxy groups are sulfated, after which, if present, remaining protective groups are cleaved, and the compound obtained is optionally converted into a pharmaceutically acceptable salt.

A stepwise condensation of the monosaccharides is possible. In general, however, building blocks consisting of D-glucose, L-idose, D-glucuronic acid or L-iduronic acid, suitably functionalized with the

required alkyl, aryl, or aralkyl groups or by temporarily protective groups, are condensed together in the desired order. In this way the (protected) saccharide unit can be prepared, which can be coupled with other saccharide units, or protected derivatives thereof. Suitable protective groups are well known in carbohydrate chemistry. Preferred protective groups include benzyl and acetyl for hydroxy groups, and methyl and benzyl for the carboxylate group of uronic acids. Other protective groups like levulinoyl, chloroacetyl, trityl, benzoyl, and the like, may be used with equal success. Coupling of the saccharides is performed in a manner known in the art, e.g. deprotection of the 1-position of the glycosyl-donor, and/or activation of this position (e.g. by making a bromide, pentenyl, fluoride, thioglycoside, or trichloroacetimide derivative) and coupling the activated glycosyl-donor with an optionally protected glycosyl-acceptor.

For the treatment of venous thrombosis or for the inhibition of smooth muscle cell proliferation the compounds of the invention may be administered enterally or parenterally, and for humans preferably in a daily dosage of 0,001-10 mg per kg body weight. Mixed with pharmaceutically suitable auxiliaries, the compounds may be compressed into solid dosage units, such as pills, tablets, or be processed into capsules or suppositories. By means of pharmaceutically suitable liquids the compounds can also be applied as an injection preparation in the form of a solution, suspension, emulsion, or as a spray, e.g. a nasal spray.

The invention is further illustrated by the following examples.

Example 1

2-(phenylmethyloxycarbonylamino)ethyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside hexakis sodium salt.

a. 2-(phenylmethyloxycarbonylamino)ethyl O-6-O-acetyl-3,4-di-O-methyl-α-D-glucopyranosyl-(1→4)-O-(methyl 2,3-di-O-methyl-β-D-glucopyranuronate)-(1→4)-O-3,4-acetyl-2-O-phenylmethyl-α-D-glucopyranoside (0,0466 mmol) was saponified in the presence of sodium hydroxide to give 2-(phenylmethyloxycarbonylamino)-ethyl O-2-O-phenylmethyl-3,4-di-O-methyl-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2-O-phenylmethyl-α-D-glucopyranoside (57 mg), which was used without further purification.

b. 2-(phenylmethyloxycarbonylamino)ethyl O-2-O-phenylmethyl-3,4-di-O-methyl-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2-O-phenylmethyl-α-D-glucopyranoside (25 mg) was stirred in *tert*-butanol under an atmosphere of hydrogen for one day in the presence of 10% Pd/C catalyst. After filtration crude 2-aminoethyl O-3,4-di-O-methyl-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-α-D-glucopyranoside was obtained and used as such in the next step.

c. 2-aminoethyl O-3,4-di-O-methyl-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-α-D-glucopyranoside (0,154 mmol) and phenylmethyloxycarbonyl chloride (0,23 mmol) were allowed to react in water (4 ml) in the presence of sodium hydrogen carbonate (35 mg). After gel filtration and evaporation of the solvent, the product (130 mg) was directly used in the sulfation step.

d. 2-(phenylmethyloxycarbonylamino)ethyl O-3,4-di-O-methyl-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-α-D-glucopyranoside (0,154 mmol) and triethylamine sulfur trioxide complex (0,7 g) were allowed to react in N,N-dimethylformamide for 24 h at 50 °C. Sodium hydrogen carbonate (1,2 g) and water (12 ml) were added and after 2 h the mixture was layered on top of a Sephadex G25 column and eluted with water. The fractions were combined and after lyophilisation 2-(phenylmethyloxycarbonylamino)ethyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside hexakis sodium salt (230 mg) was obtained.

Example 2

The product of Example 1 was converted in a known manner by hydrogenolysis into:
2-aminoethyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside hexakis sodium salt. $[\alpha]_D^{20}$ = +52° (c = 0.96; water).

This product was converted by sulfation into: 2-sulfoaminoethyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside heptakis sodium salt. $[\alpha]_D^{20}$ = +55.4° (c = 1.5; water).

The reaction of this product with phthalic anhydride gave:
2-(N-phthaloylamino)ethyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside heptakis sodium salt. $[\alpha]_D^{20}$ = +49.9° (c = 1.23; water).

Similarly, using the corresponding anhydrides, were prepared:
2-(N-succinylamino)ethyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside heptakis sodium salt. $[\alpha]_D^{20}$ = +100° (c = 0.66; water).

2-(N-trimellitylamino)ethyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside heptakis sodium salt. $[\alpha]_D^{20}$ = +47.5° (c = 1.11; water).

Example 3

methyl O-4-O-(4-sulfoaminophenyl)-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside nonakis sodium salt.

Methyl O-4-O-(4-nitrophenyl)-6-O-acetyl-2,3-O-di-phenylmethyl-α-D-glucopyranosyl-(1→4)-O-(methyl 3-O-methyl-2-O-acetyl-α-L-idopyranosyluronate)-(1→4)-O-2,3,6-tri-O-acetyl-α-D-glucopyranoside (100 mg, 0.09 mmol), obtained by the known imidate coupling of the trichloroacetimidate of O-4-O-(4-nitrophenyl)-6-O-acetyl-2,3-O-di-phenylmethyl-α-D-glucopyranoside and methyl O-(methyl 3-O-methyl-2-O-acetyl-α-L-idopyranosyluronate)-(1→4)-O-2,3,6-tri-O-acetyl-α-D-glucopyranoside, was dissolved in tetrahydrofuran (9 ml) and cooled to -5 °C. At this temperature a 30% aq. solution of hydrogen peroxide (4.5 ml) was added to the reaction mixture, and after 10 min a 1.25 M lithium hydroxide solution (4.7 ml) was added. The mixture was stirred for 1 h at -5 °C, after which time the temperature was raised to 0 °C and the mixture was stirred overnight. The reaction mixture was acidified with 6N hydrogen chloride at 0 °C to pH 1.5, after which the saponified compound was extracted with ethyl acetate. The organic layers were pooled, dried over magnesium sulfate, and evaporated to give 63 mg (84%) of methyl O-4-O-(4-nitrophenyl)-2,3-O-di-phenylmethy1-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-α-L-idopyranuronosyl-(1→4)-O-α-D-glucopyranoside, which was dissolved in methanol (8 ml). 10% Pd on charcoal (63 mg) was added and the mixture hydrogenolyzed overnight. After filtration and evaporation 27 mg (50%) of methyl O-4-O-(4-aminophenyl)-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-α-L-idopyranuronosyl-(1→4)-O-α-D-glucopyranoside were obtained.
13 mg of methyl O-4-O-(4-aminophenyl)-O-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-α-L-idopyranuronosyl-(1→4)-O-α-D-glucopyranoside were dissolved in 2 ml of dry N,N-dimethylformamide, and under an atmosphere of nitrogen 148 mg of triethylamine sulfurtrioxide complex were added. The mixture was stirred overnight at 50 °C, after which an aq. solution of sodium hydrogen carbonate was added under ice cooling. The mixture was stirred for 1 h at room temperature, concentrated to a small volume and desalted on a Sephadex G-10 column with water. The crude product obtained was purified by HPLC using a Mono-Q anion exchange column to give 11 mg (37%) of methyl O-4-O-(4-sulfoaminophenyl)-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside nonakis sodium salt. $[\alpha]_D^{20}$ = +52.2° (c = 0.67; water). Anomeric protons chemical shifts: 5.5; 5.17; and 5.15 ppm.

Example 4

In a similar way as described in the previous examples were prepared:
methyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside undecakis sodium salt. $[\alpha]_D^{20}$ = +26.5° (c = 0.46; water). Anomeric protons chemical shifts: 5.56; 5.39; 5.31; 5.14; and 5.13 ppm.

methyl O-2,3,4-tri-O-methyl-6-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside nonakis sodium salt. $[\alpha]_D^{20}$ = +55° (c = 1; water). Anomeric protons chemical shifts: 5.47; 5.42; 5.17; 5.14; and 4.67 ppm.

methyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside decakis sodium salt. $[\alpha]_D^{20}$ = +53° (c = 1; water). Anomeric protons chemical shifts: 5.56; 5.45; 5.19; 4.81; and 4.70 ppm.

methyl O-4-O-methyl-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-b-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside undecakis sodium salt. $[\alpha]_D^{20}$ = +47.5° (c = 1; water). Anomeric protons chemical shifts: 5.60; 5.42; 5.16; 5.09; and 4.66 ppm.

methyl O-2,3,4-tri-O-methyl-6-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-O-di-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside nonakis sodium salt. $[\alpha]_D^{20}$ = +46.2° (c = 1; water). Anomeric protons chemical shifts: 5.43; 5.37; 5.16; 5.09; and 5.09 ppm.

methyl O-2,3,4-tri-O-methyl-6-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside undecakis sodium salt. $[\alpha]_D^{20}$ = +46.7° (c = 0.55; water). Anomeric protons chemical shifts: 5.49; 5.48; 5.16; 5.15; and 4.76 ppm.

methyl O-4-O-methyl-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside tridecakis sodium salt. $[\alpha]_D^{20}$ = +42.2° (c = 1; water). Anomeric protons chemical shifts: 5.61; 5.48; 5.15; 4.86; and 4.76 ppm.

methyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside decakis sodium salt. $[\alpha]_D^{20}$ = +42.2° (c = 1; water).

methyl O-2-O-methyl-3,4,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-β-D-glucopyranuron osyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside tridecakis sodium salt.

methyl O-2,3-di-O-methyl-4,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside dodecakis sodium salt.

methyl O-2,4-di-O-methyl-3,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside dodecakis sodium salt.

methyl O-4-O-methyl-2,3,6-tri-O-sulfo-α-D-mannopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside undecakis sodium salt.

methyl O-2,3,4-tri-O-methyl-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside undecakis sodium salt.

2-(2-(4-fluorophenyloxy)ethoxy)ethyl O-3,4-di-O-methyl-2,6-di-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-β-D-glucopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-(2-phenylethyl)-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside undecakis sodium salt. $[\alpha]_D^{20}$ = +22.0° (c = 0.3; water). Anomeric protons chemical shifts: 4.68; 4.93; 5.21; 5.46; 5.54 ppm.

2-(2-(4-fluorophenyloxy)ethoxy)ethyl O-4-O-(4-amino-phenyl)-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-(2-phenylethyl)-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-glucopyranoside octakis sodium salt. $[\alpha]_D^{20}$ +21.9° (c = 1.2; water). Anomeric protons chemical shifts: 4.92; 5.27; 5.51 ppm.

2-(2-(4-fluorophenyloxy)ethoxy)ethyl O-4-O-[4-(phenylmethoxycarbonylamino)phenyl]-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-3-O-(2-phenylethyl)-2-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside octakis sodium salt. $[\alpha]_D^{20}$ = +20.5° (c = 0.75; water). Anomeric protons chemical shifts: 4.93; 5.27; 5.52 ppm.

methyl O-2,3-di-O-methyl-4-O-sulfo-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranuronosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranosyl-(1→4)-O-2,3-di-O-methyl-α-L-idopyranosyl-(1→4)-O-2,3,6-tri-O-sulfo-α-D-glucopyranoside tridecakis sodium salt. Anomeric protons chemical shifts: 5.40; 5.37; 5.10; 5.05; 5.05 ppm.

methyl 0-3,4-di-0-methyl-2,6-di-0-sulfo-α-D-galactopyranosyl-(1→4)-0-2,3-di-0-methyl-β-D-glucopyranuronosyl-(1→4)-0-2,3,6-tri-0-sulfo-α-D-glucopyranosyl-(1→4)-0-3-0-methyl-2-0-sulfo-α-L-idopyranuronosyl-(1→4)-0-2,3,6-tri-0-sulfo-α-D-glucopyranoside undecakis sodium salt. $[\alpha]_D^{20}$ = +48.8° (c = 1; water). Anomeric protons chemical shifts: 4.60; 5.06; 5.06; 5.44; and 5.52 ppm.

Example 5

propyl O-2,6-di-O-ethyl-3,4-di-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-2-O-sulfo-α-L-idopyranuronosyl-(1→3)-O-2,6-di-O-ethyl-4-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-2-O-sulfo-α-L-idopyranuronoside heptakis sodium salt.

propyl O-4-O-benzoyl-2,6-di-O-ethyl-β-D-galactopyranosyl-(1→4)-O-(methyl 2-O-benzoyl-3-O-ethyl-α-L-idopyranuronosyluronate)-(1→3)-O-4-benzoyl-2,6-di-O-ethyl-β-D-galactopyranosyl-(1→4)-O-(methyl-2-O-benzoyl-3-O-ethyl-α-L-idopyranuronoside uronate) (0.028 mmol) was dissolved in 2.79 ml of tetrahydrofuran. The mixture was cooled to -5 °C and 1.37 ml of a 33% hydrogen peroxide solution were added. After 10 min stirring 0.633 ml of a 1.25 M lithium hydroxide hydrate solution in water were added. After 1 h stirring the temperature was increased to 0 °C and the mixture was stirred for another 20 h. The mixture was brought to room temperature and 2.56 ml of methanol and 0.65 ml of 4 N sodium hydroxide were added. The mixture was stirred for another 20 h and acidified with diluted hydrochloric acid at 0-5 °C. The excess of hydrogen peroxide was destroyed with a 10% sodium sulfite solution in water and the mixture was evaporated to dryness. The residue was treated with 10 ml of dichloromethane-methanol (8:2), the salts were filtered, and the filtrate evaporated to dryness. The residue was purified on a Sephadex LH20 column and the pure fractions were pooled and evaporated to dryness to obtain propyl O-2,6-di-O-ethyl-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-α-L-idopyranuronosyl-(1→3)-O-2,6-di-O-ethyl-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-α-L-idopyranuronoside, which was dissolved in a mixture of 1.63 ml of dry dimethylformamide and 0.64 mmol triethylamine sulfurtrioxide complex. The mixture was stirred for 20 h at 50 °C, after which the mixture was cooled to room temperature and a mixture of 215 mg of sodium hydrogen carbonate in 2.8 ml of water were added. The mixture was stirred for 30 min and then evaporated to dryness. The residue was dissolved in water, desalted on Sephadex G-25, and the combined fractions were liophilized to give amorphous propyl O-2,6-di-O-ethyl-3,4-di-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-2-O-sulfo-α-L-idopyranuronosyl-(1→3)-O-2,6-di-O-ethyl-4-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-2-O-sulfo-α-L-idopyranuronoside heptakis sodium salt. $[\alpha]_D^{20}$ = -16.0° (c = 1; water).

Example 6

In a similar manner as described in Example 5 were prepared:

propyl O-2,6-di-O-ethyl-3,4-di-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-2-O-sulfo-α-L-idopyranuronosyl-(1→3)-O-2,6-di-O-ethyl-4-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-2-O-sulfo-α-L-idopyranuronosyl-(1→3)-O-2,6-di-O-ethyl-4-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-2-O-sulfo-α-L-idopyranuronoside decakis sodium salt. $[\alpha]_D^{20}$ = -17.5° (c = 1; water).

propyl O-2,6-di-O-ethyl-3,4-di-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-ethyl-2-O-sulfo-α-L-idopyranuronoside tetrakis sodium salt. $[\alpha]_D^{20}$ = -9.7° (c = 1; water).

4-methoxyphenyl O-3-O-methyl-2,4-di-O-sulfo-α-L-idopyranuronosyl-(1→3)-O-6-O-methyl-2,4-di-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranuronosyl-(1→3)-O-6-O-methyl-2,4-di-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranurosyl-(1→3)-O-6-O-methyl-2,4-di-O-sulfo-β-D-galactopyranoside tridecakis sodium salt. Anomeric protons chemical shift: 5.44; 5.42; 5.33; 5.21; 4.67; 4.65 ppm.

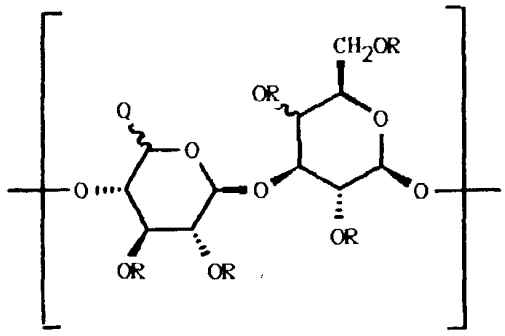
4-methoxyphenyl O-3-O-methyl-2,4-di-O-sulfo-α-L-idopyranuronosyl-(1→3)-O-6-O-methyl-2,4-di-O-sulfo-β-D-galactopyranosyl-(1→4)-O-3-O-methyl-2-O-sulfo-α-L-idopyranurosyl-(1→3)-O-6-O-methyl-2,4-di-O-sulfo-β-D-galactopyranoside nonakis sodium salt. Anomeric protons chemical shift: 5.44; 5.42; 5.22; 4.66 ppm.

4-methoxyphenyl O-3-O-methyl-2,4-di-O-sulfo-α-L-idopyranuronosyl-(1→3)-O-6-O-methyl-2,4-di-O-sulfo-β-D-galactopyranoside pentakis sodium salt. Anomeric protons chemical shift: 5.29; 5.34 ppm.

Claims

1. A sulfated glycosaminoglycanoid derivative or a pharmaceutically acceptable salt thereof, in which the functional N-sulfate, N-acetate, and hydroxy groups, are replaced by alkoxy, aryloxy, aralkoxy, O-sulfate, or OALK(OALK)$_n$OX groups, wherein ALK is an aliphatic hydrocarbon group, n is 0-5, and X is an alkyl or aryl group, provided that at least two functional groups are not replaced by O-sulfate.

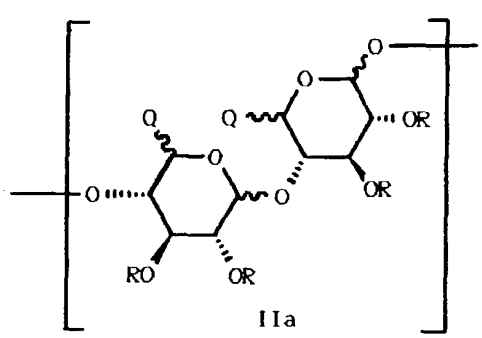
2. The sulfated glycosaminoglycanoid derivative of claim 1, comprising the disaccharide unit having the formula I



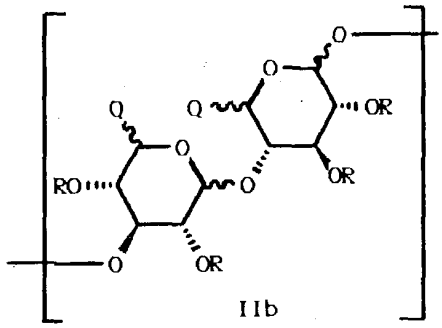
I

in which the twitched lines denote an α or β bond, each of the groups R are independently selected from the group consisting of alkyl, aryl, aralkyl, and sulfate; and
Q is selected from carboxylate and the CH_2OR group;
or a pharmaceutically acceptable salt thereof.

3. The sulfated glycosaminoglycanoid derivative of claim 1, comprising the disaccharide unit having the formula IIa or IIb



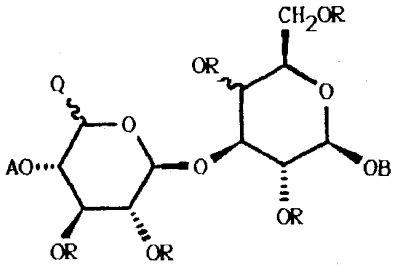
IIa



IIb

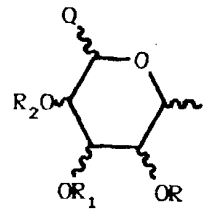
in which the twitched lines denote an α or β bond, each of the groups R are independently selected from the group consisting of alkyl, aryl, aralkyl, and sulfate, and each of the groups Q are independently selected from the group consisting of carboxylate and the CH_2OR group, or a pharmaceutically acceptable salt thereof.

4. The sulfated glycosaminoglycanoid derivative of claim 1, having the formula III



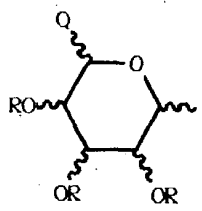
III

in which the twitched lines denote an α or β bond, each of the groups R are independently selected from the group consisting of alkyl, aryl, aralkyl, and sulfate;
Q is selected from carboxylate and the CH_2OR group;
A is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, and a carbohydrate group having the formula IV



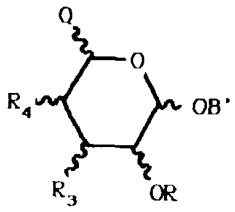
IV

in which the twitched lines, Q, and R have the previously given meanings, one of the groups R_1 and R_2 is alkyl, aryl, aralkyl, or sulfate, whereas the other is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, and a carbohydrate group having the formula V



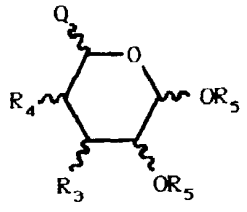
V

in which the twitched lines, Q, and R have the previously given meanings; and
B is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, $ALK(OALK)_nOX$ (wherein ALK is an aliphatic hydrocarbon group, n is 0-5, and X is an alkyl or aryl group), and a carbohydrate group having the formula VI



VI

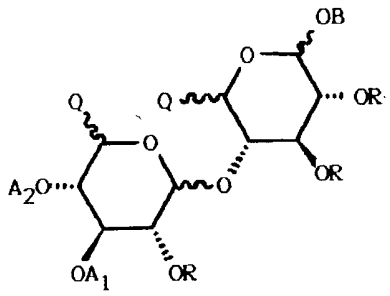
in which the twitched lines, Q, and R have the previously given meanings, one of the groups R_3 and R_4 is alkoxy, aryloxy, aralkoxy, or O-sulfate, whereas the other is a bond, and B' is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, $ALK(OALK)_nOX$ (wherein ALK, n, and X have the previously given meanings), and a carbohydrate group having the formula VII



VII

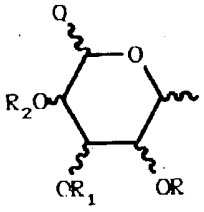
in which the twitched lines, Q, R_3, and R_4 have the previously given meanings, and each of R_5 has independently the meaning previously given for R or is $ALK(OALK)_nOX$ (wherein ALK, n, and X have the previously given meanings), or a pharmaceutically acceptable salt thereof.

5. The sulfated glycosaminoglycanoid derivative of claim 1, comprising the disaccharide unit having the formula VIII



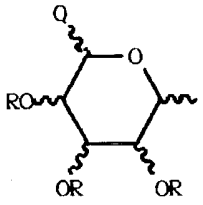
VIII

in which the twitched lines denote an α or β bond, each of the groups R are independently selected from the group consisting of alkyl, aryl, aralkyl, and sulfate, each of the groups Q are independently selected from the group consisting of carboxylate and the CH_2OR group, one of the groups A_1 and A_2 is alkyl, aryl, aralkyl, or sulfate, whereas the other is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, and a carbohydrate group having the formula IV



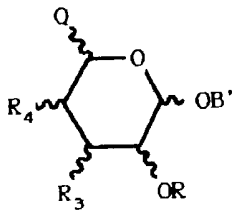
IV

in which the twitched lines, Q, and R have the previously given meanings, one of the groups R_1 and R_2 is alkyl, aryl, aralkyl, or sulfate, whereas the other is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, and a carbohydrate group having the formula V



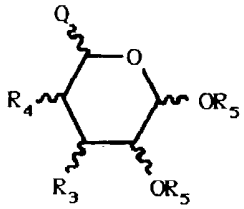
V

in which the twitched lines, Q, and R have the previously given meanings; and
B is selected from the group consisting of alkyl, aryl, aralkyl, sulfate, $ALK(OALK)_nOX$ (wherein ALK is an aliphatic hydrocarbon group, n is 0-5, and X is an alkyl or aryl group), and a carbohydrate group having the formula VI



VI

in which the twitched lines, Q, and R have the previously given meanings, one of the groups R_3 and R_4 is alkoxy, aryloxy, aralkoxy, or O-sulfate, whereas the other is a bond, and B' is selected from alkyl, aryl, aralkyl, sulfate, $ALK(OALK)_nOX$, wherein ALK, n, and X have the previously given meanings, and a carbohydrate group having the formula VII



VII

in which the twitched lines, Q, R_3, and R_4 have the previously given meanings, and each of R_5 has independently the meaning previously given for R or is $ALK(OALK)_nOX$ (wherein ALK, n, and X have the previously given meanings), or a pharmaceutically acceptable salt thereof.

6. The sulfated glycosaminoglycanoid derivative of any one of claims 1-5 for use in therapy.

7. A process for the preparation of the sulfated glycosaminoglycanoid derivative of any one of claims 1-5, characterized in that protected monosaccharides are coupled to give protected disaccharides, which are optionally further coupled to tri- to hexasaccharides, after which the protective groups are partially or completely cleaved and free hydroxy groups are sulfated, after which, if present, remaining protective groups are cleaved, and the compound obtained is optionally converted into a pharmaceutically acceptable salt.

8. A pharmaceutical composition comprising the sulfated glycosaminoglycanoid derivative of any one of claims 1-5 and pharmaceutically acceptable auxiliaries.

9. A use of the sulfated glycosaminoglycanoid derivative of any one of claims 1-5 for the manufacture of a medicament, having antithrombotic activity or inhibiting smooth muscle cell proliferation.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 20 2507

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-0 301 618 (SANOFI) * page 1, line 1 - line 26; claim 1 *	1,3,6-9	C07H11/00 C07H15/04
Y	* page 1, line 1 - line 26; claim 1 *	1-9	C07H15/26 C07H15/08
Y	EP-A-0 300 099 (AKZO) * page 1, line 1 - line 26; claim 1 *	1-9	A61K31/70
X	US-A-3 017 407 (F.J. PETRACEK) * claims 1-19 *	1,3,6,8,9	
X	EP-A-0 230 023 (MARION LABORATORIES) * claims 1,4 *	1,3,8	
X	GB-A-1 110 939 (MEITO SANGYO) * claims 1,13,15; table 2 *	1,3,8	
E	EP-A-0 454 220 (AKZO) * page 4, line 30 - page 6, line 30; claims 1-5 *	1,3,5	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

C07H
A61K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 SEPTEMBER 1992	BRENNAN J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document

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